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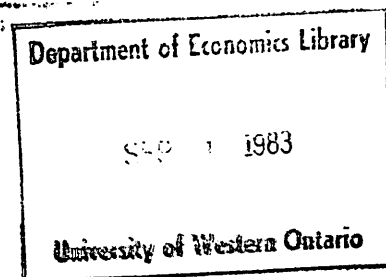
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RATIONING AND DETERRENCE: GENERAL  
THEORY AND THE EXAMPLE OF NEW  
ZEALAND'S "CARLESS DAYS" SCHEME

by

David Walker and Richard Manning



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RATIONING AND DETERRENCE: GENERAL THEORY AND THE  
EXAMPLE OF NEW ZEALAND'S "CARLESS DAYS" SCHEME<sup>\*</sup>

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Abstract

Penalties may only be imposed after a crime is committed. The traditional rationing model is reformulated to encompass this fact. Increases in the expected fine for exceeding the ration decompose into price and income effects. On "carless days" the motorist's petrol ration is zero, so the theory may be used to interpret New Zealand's experience. The main effect of carless days was to redistribute welfare. An estimate shows that the perceived probability of detection while breaking the regulations was low. So was the real probability. New Zealand shared Becker's view that it is best that lawbreakers be seldom caught.

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## Introduction

To cope with a reduction in domestic oil stocks, which resulted from internal disruptions in Iran, in 1979 New Zealand introduced "carless days" for motorists. The carless days regulations operated in this way. At the time of annual vehicle registration, each owner had to nominate a day of the week as his carless day. He was then issued with a label to be displayed on the windscreen of his vehicle. This label showed the chosen carless day. On that day, it was illegal for anyone to drive the vehicle.<sup>1</sup> The regulation came into force on July 30 1979, and, after several temporary relaxations, were suspended on May 13 1980, and finally abolished from December 22 1980. New regulations have since been drafted for the reinstatement of carless days if this proves to be necessary.

This paper provides an economic analysis of the costs imposed in New Zealand by the carless days scheme. There is historical interest in this, but there are also lessons for future policymakers. More importantly, in order to perform the analysis it is necessary to reconsider a part of the received theory of consumer behavior.

The carless days regulations imposed a particular form of rationing on New Zealand motorists. For those people with access to only one vehicle,<sup>2</sup> on their carless day their petrol "ration" was zero. Not everyone was constrained by their ration, however. A glance over any parking area revealed vehicles that must have been driven illegally. Yet petrol consumption did fall following the imposition of the carless days regulations (see Table 1: This will be explained in more detail later). The principal purpose of this

paper is to present a modified analysis of rationing consistent with the fact of incomplete compliance.

The established theory of rationing was developed during, and immediately following, World War II. In that period, rationing was in force in many countries. Enke (1942), Henderson (1947), Rostow (1946), Scitovsky (1942), and Tobin (1951, 1952) all wrote on the problem. Of course, the definitive mathematical analysis of rationing was that of Samuelson (1948). This type of analysis proceeds on the assumption that the ration constraint is binding, even though individuals have a clear incentive to break it. In some circumstances this assumption may be justified. As Galbraith (1946, p. 480) notes "...a community that has come to regard war as a tragedy stigmatizes illegal profiteering as a more heroic age did not". That may be so. But in fact rationing is backed up by laws which seek to deter those that would break the constraint.

The next section of this paper considers the problem of a consumer faced with a legal system which imposes penalties for non-compliance with a rationing constraint. Slutsky-like results are found which link the penalties to regular price effects. These provide a way of measuring, in monetary terms, the costs imposed on consumers by rationing. The subsequent section applies these ideas to the carless days regulations. A brief concluding section then summarizes what has been learned.

### Rationing and Deterrence

The model of consumer behavior that is now developed is complex enough to give insight into the way rationing operates, while retaining enough simplicity to be tractable. As will become plain, some awkward points are smoothed over because to do otherwise would complicate the analysis with little result.

Let there be two commodities, the amounts of which consumed are  $q_1$  and  $q_2$ , respectively. This gives utility to the consumer according to

$$(1) \quad \text{utility} = u(q_1, q_2); \quad q_1, q_2 \geq 0$$

where  $u$  is a quasi-concave utility function increasing in both arguments.

The prices of the commodities are denoted as  $p_1$  and  $p_2$ , and the consumer has income  $Y$  to spend. The budget constraint is thus written as

$$(2) \quad p_1 q_1 + p_2 q_2 = Y$$

Commodity 1 is rationed.<sup>3</sup>  $R \geq 0$  denotes the ration. Provided that no more than  $R$  of commodity 1 is consumed the rationing regulations are not broken, so their penalty provisions are irrelevant. Only if more than  $R$  of the rationed commodity is consumed does the consumer become liable. The consequences of breaking the rationing constraint will be taken into account by the consumer. There are two outcomes possible. Either the consumer is not detected breaking the constraint, or he is detected and is penalized. The probability of detection is  $\pi$ ,  $0 \leq \pi \leq 1$ , and the penalty is a fine of amount  $F$ .<sup>4</sup> More details of these will be given later. For the present, some discussion of the timing of the various actions is needed. There is an important legal principle overlooked in the conventional formulation of the rationing problem.

It is surely a test of the fairness of a legal system that no one is convicted of an offence before offending. Thus, a robber must rob before being convicted (although it may also be an offence to plan a robbery: but then robbery is not the offence). In the present case, the consumer can only be fined for exceeding his ration after he has actually done so. The consumer must plan his consumption, and carry out his plan, before any penalty can be imposed.

To see the consequence of this point for the theory, suppose that there are no costs directly associated with exceeding the ration, other than buying the commodity. (This is obviously reasonable with carless days. Should there be ration coupons, it is assumed that they can be costlessly forged. However, this is not a critical assumption: It is easy to include in the later analysis a term reflecting all costs incurred in exceeding the ration.) Now interpret the problem defined by (1), (2) and rationing as that of a consumer who lives for only a single period. It is quite clear that the consumer will act as if there is no rationing. If he buys more than his ration of commodity 1, and if this is detected, the fine will be imposed. However, the consumer has already spent all of his income, so the fine cannot be paid. The consumer cannot be affected by the fine. The timing of actions, and legal reactions, ensure that rationing is ineffective in this setup. An alternative, dynamic formulation is called for. What is now proposed is a development of the problem (1), (2) to include rationing in a way which allows interpretation as a dynamic system.

In maximizing (1) it is now assumed that a constraint in addition to (2) applies. This constraint is

$$(3) \quad p_1 q_1 + p_2 q_2 \leq Y - \pi F, \quad q_1 > R$$

where  $\pi F$  is, of course, the expected value of the fine that may be levied if the rationing constraint is broken. This may be interpreted as the budget constraint of a consumer who has set aside from his income enough to pay the expected value of the fine. More may be said about this expected value.

It is reasonable to believe that minor infractions of regulations are less likely to be detected than are major breaches. Similarly, the penalty

imposed for an offence is usually scaled according to its seriousness.

Both  $\pi$  and  $F$  are increasing functions of the extent to which the ration is exceeded.<sup>5</sup> The simplification is adopted that

$$(4) \quad \pi F = (q_1 - R)f; \quad f > 0, \quad q_1 > R.$$

That is, the expected fine is a linear function of the amount consumed above the ration.<sup>6</sup> Substituting from (4) into (3) gives

$$(3') \quad (p_1 + f)q_1 + p_2 q_2 \leq Y + fR$$

The problem considered is to maximize (1) subject to (2) and (3'), with non-negativity imposed on the variables. Note that it is not necessary to restrict (3') to apply only if  $q_1 > R$ . It is easily checked that (2) holds with  $=$  and (3') holds with  $<$  if  $q_1 < R$ , while if  $q_1 > R$ , (2) holds with  $<$  and (3') holds with  $=$ . How this problem may be interpreted is now considered.

Suppose that the consumer survives for a large number of periods, in all of which his income, and prices, and the rationing system, are the same. If there is actuarially fair, costless, insurance against fines, the premium would be  $\pi F$  per period. Under these conditions the problem of the consumer in every period is defined by (1), (2) and (3) (or (3') in particular).

Of course, actuarially fair, costless, insurance does not exist. More importantly, it is simply illegal to operate an insurance scheme which pays out when the insured person breaks a law. However, if there are perfect capital markets and a zero rate of interest the same result can be attained. The consumer can save at the rate  $\pi F$ , and so build up a fund to pay fines in the future, or to pay off any borrowing done to cover early fines.<sup>7</sup> The assumption of a zero rate of interest is consistent with the implied absence of time preference. It merely alters details to assume otherwise.



Formulating the rationing problem in this way requires that the consumer be able to shift risk, so that his financial arrangements can be separated from his consumption decisions. From this fact, it follows that a given level of compliance with the rationing regulations can be achieved by a low detection rate, and a sufficiently big fine. Since society's resources are used up in detecting and prosecuting offenders, this is clearly preferable to trying for a high detection rate coupled with a low fine. With reference to "optimal" levels of any type of offence, Becker (1968, pp. 183-185, 191-193) was first to make this explicit. He did not assume that offenders could shift risk, however, and his result applied for risk-neutral and risk-averse agents.<sup>8</sup> Details of the enforcement of New Zealand's careless days regulations are given later. These indicate a low detection rate. However, in view of the consequences of these regulations, it is difficult to see what defensible social welfare function was being maximized.

Conditions necessary (and sufficient) for a solution to the consumer's problem can be written down using the Kuhn-Tucker Theorem.<sup>9</sup> Rather than do this, the familiar structure of neo-classical consumer theory may be used to give the interesting results directly. These results concern the impact on demand of changes in the rationing regulations. To see them, note that (3') is the only tight constraint when rationing is a limitation on the consumer. An increase in  $f$  has two effects: It is effectively an increase in the price of the rationed commodity, and it also increases the "income" of the consumer (see (3')). The first effect is quite clear: increased consumption of the rationed commodity raises the amount the consumer expects to pay in fines in exactly the same fashion that it raises his expenditure on the commodity, so that an increase in the rate of a fine operates in the same way as an increased

price. The second effect is more subtle. It arises because the consumer is "endowed" with a ration,  $R$ . Since this quantity may be consumed without penalty, it has a value  $fR$ . An increase in  $f$ , or  $R$ , raises the value of this "endowment".

This said, the main results may be written down. These are

$$(5) \quad \frac{\partial q_i^*}{\partial f} = \frac{\partial q_i^*}{\partial p_1} + R \frac{\partial q_i^*}{\partial Y}, \quad i=1,2$$

and

$$(6) \quad \frac{\partial q_i^*}{\partial R} = f \frac{\partial q_i^*}{\partial Y}, \quad i=1,2$$

where  $q_i^*$  denotes the optimal rate of consumption of the  $i^{\text{th}}$  commodity.  $\partial q_i^* / \partial p_1$  and  $\partial q_i^* / \partial Y$  are the usual price of commodity 1 and income effects on the demand for commodity  $i$  (evaluated at  $p_1 + f$  and  $Y + fR$ , of course).

If the rationed commodity is normal, then  $\partial q_1^* / \partial p_1 < 0$  and  $\partial q_1^* / \partial Y > 0$ . In this case, an increase in the fine for, or probability of detection of, an offence against the rationing regulations imparts two opposing tendencies to the demand for the rationed commodity. However, the net effect is negative. To see this, decompose  $\partial q_1^* / \partial p_1$  by Slutsky's equation. Then (5) yields

$$(7) \quad \frac{\partial q_1^*}{\partial f} = \left. \frac{\partial q_1^*}{\partial p_1} \right|_u - (q_1^* - R) \frac{\partial q_1^*}{\partial Y} < 0$$

since  $q_1^* > R$ , by hypothesis. While an increase in the expected fine for breaking rationing regulations acts like a price increase of the same magnitude, the former effect is smaller than the latter as long as the ration is positive (because of the additional income effect).

### Carless Days in New Zealand

The preceding analysis is now applied to rationing by the use of carless days. To do this, take the decision period to be one day. On the consumer's carless day  $R = 0$ , whereas there is no restriction on any other day of the week.<sup>10</sup> From (5), on a carless day

$$(8) \quad \frac{\partial q_1^*}{\partial f} = \frac{\partial q_1^*}{\partial p_1}$$

Therefore the expected fine under the carless days regulations is equivalent to a petrol price increase of the same amount. Theoretical arguments justify (8). Its usefulness is now explored by considering what happened when carless days regulations were imposed in New Zealand.

Table 1 allows month-by-month comparisons of petrol deliveries in 1978 and 1979 in Christchurch and adjacent regions.<sup>11</sup> The size of the storage facilities ensures that there is a lag of about two weeks between petrol use by motorists and replacement deliveries made by oil companies. For example, a part of deliveries made in September are to replace petrol used in August.

Seasonal fluctuations are eliminated if changes are calculated from the same month's deliveries in the previous year. It is clear that deliveries rose at the beginning of 1979, and fell, dramatically, from May onwards.<sup>12</sup> Since carless days were not introduced until July 30 they did not cause all of this decline. However, the government-set retail price of petrol was increased by 24.8 per cent on May 17, 1979. Three natural periods are thus suggested. Table 2, derived from Table 1, shows these.

TABLE 1: Monthly Petrol Deliveries by Oil Companies

(in millions of litres)

	<u>Jan.</u>	<u>Feb.</u>	<u>Mar.</u>	<u>Apr.</u>	<u>May</u>	<u>June</u>	<u>July</u>	<u>Aug.</u>	<u>Sept.</u>	<u>Oct.</u>	<u>Nov.</u>	<u>Dec.</u>
1978	16.78	15.90	17.43	15.11	17.57	16.90	15.29	17.46	16.24	17.18	18.07	16.75
1979	17.51	16.30	17.84	16.34	15.97	16.09	14.75	15.87	11.57	18.24	16.34	16.68
% change	+ 4.35	+ 2.52	+ 2.35	+ 8.14	- 9.11	- 4.79	- 3.53	- 9.11	-29.76	+ 6.17	- 9.57	- 0.42

Source: Christchurch City Council.

TABLE 2: Petrol Deliveries by Oil Companies, in Periods

(in millions of litres)

	<u>Jan.-Apr.</u>	<u>May-Aug.</u>	<u>Sept.-Nov.</u>
1978	65.22	67.22	51.49
1979	67.99	62.68	46.15
% change	+ 4.25	- 6.75	-10.37

Before the price rise in May 1979, petrol use was up 4.25 per cent on the previous year. Following the price rise (but before carless days can have had any effect), petrol use was down 6.75 per cent on that a year earlier. It seems that the 24.8 per cent price rise resulted in a fall in petrol consumption of about 11 per cent. This indicates a price elasticity of demand for petrol of about 0.4.<sup>13</sup> This figure will be used here. In the last part of the year, when the price rise and carless days were in effect, petrol consumption fell a further 3.62 per cent. This may be attributed to carless days. (The December figures are omitted, since carless days were relaxed during the Christmas holiday period.) It is in line with the official claim (made without supporting evidence) that the reduction in petrol use due to carless days was 3 per cent. For the present discussion this figure will be used.

With a price elasticity of demand of 0.4, the across-the-board price increase which would have reduced aggregate petrol use by the same amount as carless days was 7.5 per cent. This would have raised the price of premium grade petrol by 2.9c/litre (from 38.6c/litre to 41.5c/litre). This effect was instead achieved by the penalty provisions of the carless days regulations, which are claimed here to be equivalent to a price rise.

A maximum fine of \$400 was provided for offenders in the carless days regulations. Many vehicles were exempted from the regulations, so they could be driven on their carless day without penalty. By the time that carless days were suspended, about 600,000 vehicles were exempted from the regulations. This was approximately 43 per cent of 1.4 million vehicles registered.<sup>14</sup> Only those not exempted were subject to the

penalties. Reductions in petrol use came from this group.

Using the available figures as a guide, and assuming that petrol use was the same on average before the regulations for both those liable and those exempt, it seems that petrol use declined by 5 per cent in the affected group (taking 60 per cent of motorists to be affected by carless days, that is  $3/0.6$ ).<sup>15</sup> If it is further assumed that petrol use was much the same on every day of the week (which is perhaps not borne out by the distribution of exemptions: But if it were true, then the observed distribution of exemption might arise by chance), this suggests that the average user of petrol reduced his consumption by 35 per cent on his carless day. In view of the elasticity of demand, the price rise (or its equivalent) needed to achieve this reduction is 87.5 per cent. Those subject to carless days regulations would, on average, have acted in the same way if they had faced a petrol price of (approximately) 72.4c/litre. The loss in consumer surplus of the average motorist on his carless day can be calculated from these figures.<sup>16</sup>

If  $q_1^*$  denotes the daily petrol use of the average motorist, then his loss of consumer surplus on his carless day is (approximately, linearizing the demand curve)

$$\begin{aligned} (9) \quad L &= \frac{1}{2}(72.4 - 38.6)1.65q_1^* \\ &= 27.89q_1^* \end{aligned}$$

where  $L$  is measured in cents. That is, the average motorist lost consumer surplus on his carless day at a rate greater than 27 cents for each litre normally consumed. An order-of-magnitude estimate of the total loss of

consumer surplus due to the operation for ten months of the carless days regulations may be obtained from (9).

Average daily petrol consumption was about 3.425 litres (per vehicle) in the absence of carless days.<sup>17</sup> Therefore the average motorist lost about \$0.96 in surplus on his carless day ( $27.89 \times 3.425 = 95.5$ ). In the whole country, about 800,000 vehicles each week had a carless day, so the total weekly loss of consumer surplus due to carless days was \$768,000. Before their suspension, the carless days regulations were in force for 41 weeks, implying an aggregate loss of surplus from carless days of \$31.488 million.

The previous calculation of the loss of consumer surplus from carless days is based on the maintenance of the official price, which would have resulted in no reduction in petrol consumption. It is, perhaps, more interesting to calculate the gains and losses from carless days in relation to the first-best way of reducing petrol consumption by 3 per cent, which (as previously noted) required an across-the-board price rise of 7.5 per cent, from 38.6c/litre to 41.5c/litre. This would have reduced average daily petrol consumption to (0.97)(3.425) litres. Relative to the alternative uniform price,

$$(10) \quad L = \frac{1}{2}(72.4 - 41.5)(0.97 + 0.65)(3.425) \\ = 85.7 \text{ cents}$$

is the loss of consumer surplus to the average motorist on his carless day. On the other hand, every motorist who was not affected by the regulations each day gained surplus relative to uniform pricing. This gain is

$$(11) \quad G = \frac{1}{2}(41.5 - 38.6) \times 1.97 \times 3.425$$

$$= 9.8 \text{ cents.}$$

In a week, the net loss of surplus of the motorists not exempted from the carless days regulations was therefore

$$(12) \quad L - 6G = 26.9 \text{ cents.}$$

The total loss of net consumer surplus of the motorists unable to avoid carless days was \$8.832 million (= \$(41 \times 800,000 \times 0.269)). The gain to the exempted motorists was \$16.876 million (= \$(41 \times 600,000 \times 7 \times 0.098)). The exemption provisions in the carless days regulations resulted in a huge transfer to those able to take advantage of them. The sense that this was so was one reason why the regulations were very unpopular.

Even within the group unable to obtain exemptions there were distributional effects. Despite the apparent equity of carless days, the method of enforcement ensured that, as usual, more wealth enabled greater consumption. Although no figures are available here to quantify this claim, it is clear from the theory (and from the fact that wealthy people bought a second car to avoid the regulations). Petrol is a normal commodity. More of it is bought as income rises, even if its "price" is raised by threat of a fine for exceeding the ration.

From (8), the perceived probability of being detected while driving on a carless day can be calculated for the "average" motorist. Although the maximum fine was not usually imposed,<sup>18</sup> it will be assumed here as a guide (as previously noted, there are costs of being detected in addition to the fine: at least some of these are then allowed for). Per litre,



this fine is 11,679 cents ( $= 40,000/3.425$ ). However, the expected fine per litre is 33.8 cents. Therefore the perceived probability of being detected is 0.00289 ( $= 33.8/11,679$ ). The "average" motorist thought there were about 3 chances in 1000 of being fined for breaking the carless days regulations. While this may seem low, it is in keeping with a more objective measure of the probability of detection. The Ministry of Transport reported 3,136 prosecutions under the Carless Days Regulations. This was about 76 each week. A survey by Eliot et al (1980) revealed that 5 to 10 per cent of motorists regularly drove on their carless days. Using the lower limit, this suggests a detection rate of  $76/40,000$ , or about 2 in a 1000. This is the same order of magnitude as the perceived rate found before.<sup>19</sup> The difference can be explained by the roughness of the data, and by the process through which the public learned about the enforcement of the regulations. Initial expectations of prosecution were high, and subsequent expectations were revised down in the light of experience towards the true rate. This process also explains the fall off in the effectiveness of the regulations over time. Finally, these calculations suggest that the authorities in New Zealand shared the view that the law is best upheld by a fine which is seldom applied.

#### Concluding Comments

It is well known that a "shadow price" can be associated with a quantitative constraint (such as the usual rationing constraint). This paper points out that quantitative restrictions on economic agents must be buttressed by legal means of enforcement, and these provide (in principle)

a way of measuring the cost of the restrictions. Individual behavior depends on these costs. With reference to New Zealand's Carless Days Regulations, it is demonstrated that an outcome of a quantitative constraint is a redistribution of welfare in a way different from that suggested by the egalitarian formulation of the rationing model. Furthermore, the data seem to support the revised form of the rationing model that is presented here. A way of estimating the impact of quantitative regulations is thus suggested. This is to look at the expected fine (or other penalty) implied by the ease with which offenders can be detected, and the legal penalties that may be imposed on them. This is equivalent to a price increase, so the actual impact can be predicted from the elasticity of demand (or supply; or both).

FOOTNOTES

\*This paper develops the earlier analysis of Walker (1982).

Geoff Angus and David Wilton are thanked for their comments.

<sup>1</sup>Exemptions were granted, of course, to those who would otherwise suffer "hardship". The proportion of vehicles exempted from the regulations is given later.

<sup>2</sup>One way of avoiding the effects of the regulations was to buy a second vehicle. It was commonly said that used-car prices rose when carless days were announced. However, most families in New Zealand have only one vehicle.

<sup>3</sup>Commodity 2 may be regarded as a "composite commodity". Alternatively, it is not difficult, in principle, to extend the present analysis to the n-commodity case. There are no surprises if this is done, so the simple case of two commodities, with easy diagrammatic interpretations, is retained here.

<sup>4</sup>It is assumed that detection results in the imposition of a penalty. Of course, not every offender detected is prosecuted, and not everyone prosecuted is convicted. Perhaps it would be better to refer to the "probability of conviction". However, offenders bear costs even if they are not convicted, and not all penalties on those convicted are identical. That said,  $F$  may be interpreted as some kind of "average" cost to those detected breaking the regulations.

<sup>5</sup>Of course, they are also functions of other variables. Both are increased for previously convicted offenders, for example. These factors are relevant, but would unnecessarily complicate the present analysis if included.

<sup>6</sup>Since  $\pi$  is bounded by 0 and 1,  $F$  is bounded by 0 and the legal maximum fine, and  $(q_1 - R)$  is unbounded, it is clear that (4) is an approximation to the true relationship. However,  $\pi F$  is small in relation to  $Y$ , so that the linearization is reasonable.

<sup>7</sup>In reality,  $\pi F$  is often a very small fraction of  $Y$ . For some offences (such as parking over the limit in metered areas) some people (such as sales representatives) do plan their finances in this way. They expect to be fined, and set aside some money to pay the fine, building up a "cookie-jar" fund if it is not worthwhile setting up a bank account for this purpose.

<sup>8</sup>Recently, Polinsky and Shavell (1979, p. 880) argued that Becker's result on the probability of detection "does not seem realistic", claiming that his mistake arose from a failure to "properly take into account the possibility that individuals may be risk averse". But see Becker (1968, pp. 183-184)!

<sup>9</sup>These conditions are given in Walker (1982). So are the manipulations which "prove" the later results (5) and (6).

<sup>10</sup>Several other "petrol conservation" measures were also adopted in New Zealand. There were tightened speed limits, and a ban on weekend petrol sales (which drove out of business many firms in tourist resorts, and led to some fiery car crashes in which cans of petrol were ignited). These had marginal effects on total petrol usage, so they may be ignored.

<sup>11</sup>These figures are reported to the Christchurch City Council to determine the amounts due from the oil companies as payment of a small levy which is used to finance road works. The C.C.C. acts as a collection agent for other local bodies. The region covered includes both urban and rural

areas, so it is a good cross-section of the whole country.

<sup>12</sup>The figures for September and October are anomalies. Deliveries were abnormally low in September 1979, because there was a general strike, and fewer working days than in most months. October deliveries were abnormally high, as deliveries caught up.

<sup>13</sup>Hughes (1980) found a much lower short-run price elasticity for petrol in New Zealand (about 0.13). There are econometric reasons to suspect his estimates are biased. Also, his estimate is lower than some found for other places (see Houthakker and Verleger (1973), for instance). In the circumstances, the estimate here is not unreasonable.

It might also be noted that there is no identification problem with the present estimate. The price is fixed, and there were no "shortages", so price and sales data do give points on the demand curve.

<sup>14</sup>It is clear that little confidence can be placed in these figures. Obviously the number of vehicles registered fluctuated over the period in question. The number of exemptions is said to be a "final" figure, and it clearly increased a lot from the beginning of the scheme. The number of exemptions granted for each day of the week is available from the Ministry of Energy, but these numbers must be suspect, since they are expressed in thousands! The following table shows the distribution of carless days, and exemptions.

Day	Mon	Tues	Wed	Thurs	Fri	Sat	Sun	Total
# vehicles	179,200	348,000	386,400	161,000	46,200	77,000	205,800	1,403,600
# exempt	72,000	156,000	180,000	84,000	12,000	12,000	84,000	600,000

TABLE 3: Distribution of Carless Days, and Exemptions, by Day-of-the-Week

Source: Ministry of Energy, Wellington.

<sup>15</sup>Unfortunately there is no evidence on this matter. Plausible stories can be invented to support the view that big users of petrol sought exemptions, so that the rest saved more than 5 percent. But so can stories be told which argue the opposite.

<sup>16</sup>Willig (1976) defended the use of demand curves as a basis for consumer surplus measures in practice on the grounds that the error associated with them is likely to be small in comparison with the statistical errors associated with estimated demand curves. See also Hausmann (1981). The relevance of this argument to the present case is obvious. The demand "estimates" here are of the crudest sort.

<sup>17</sup>From Table 1, total consumption in Christchurch and adjacent regions was 200 million litres in 1978. Some 160,000 vehicles were registered there. This gives an annual consumption rate per vehicle of 1250 litres; dividing by 365 gives the figure used here.

<sup>18</sup>There are no statistics available on actual sizes of penalties.

<sup>19</sup>Notice that the fact that some people did not drive on their carless day (because they could not "afford" to) does not affect the relevance of the perceived rate calculated here.

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